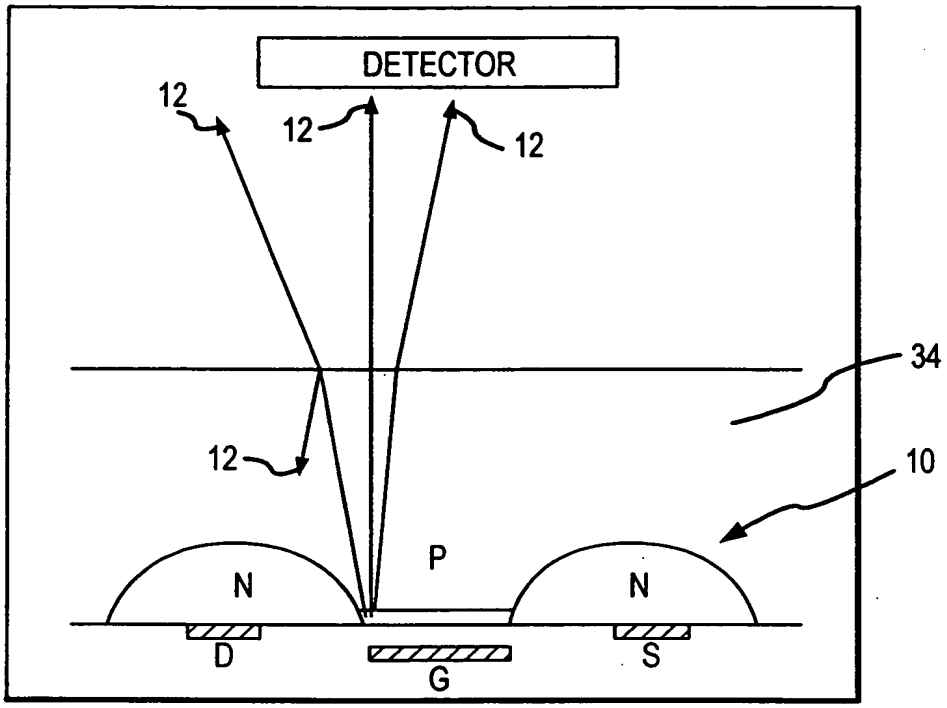


FIG.A (BACKGROUND)

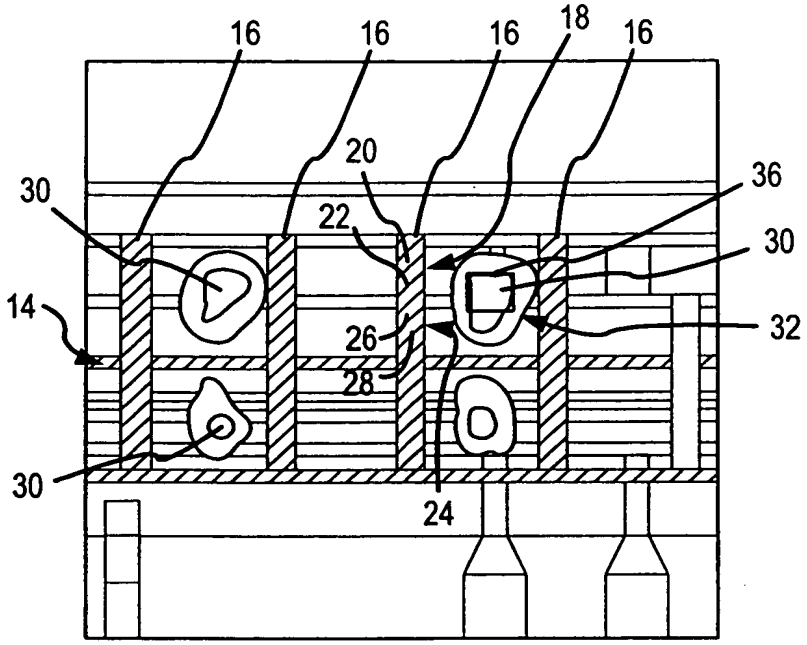


FIG. B (BACKGROUND)

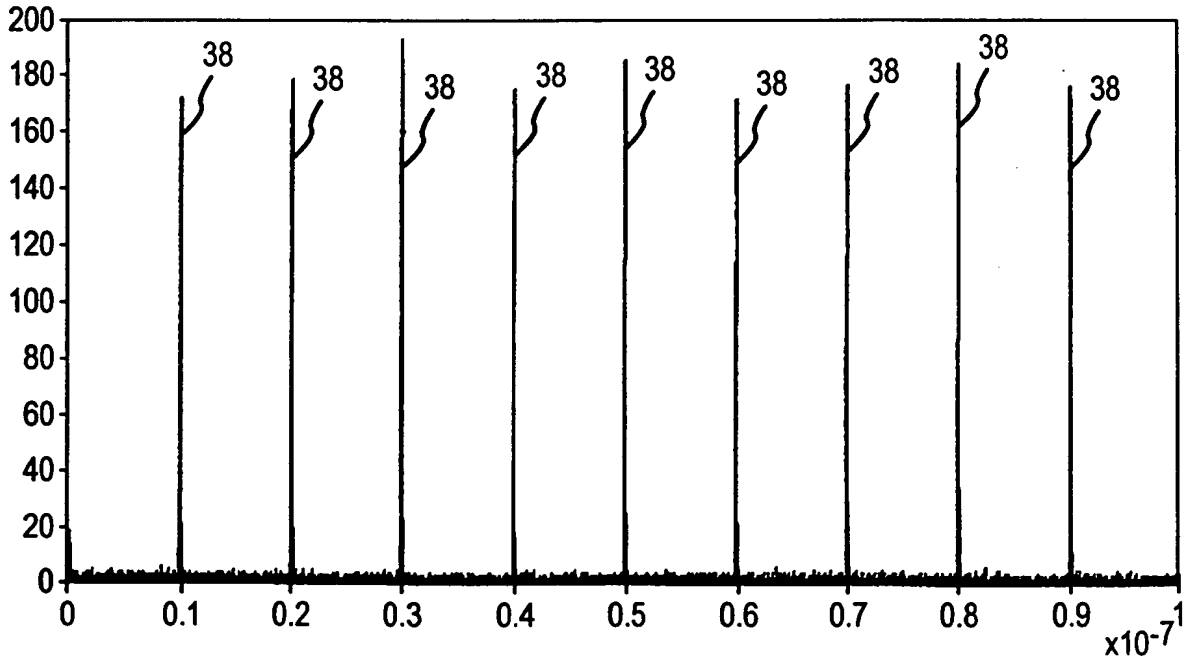


FIG. C (BACKGROUND)

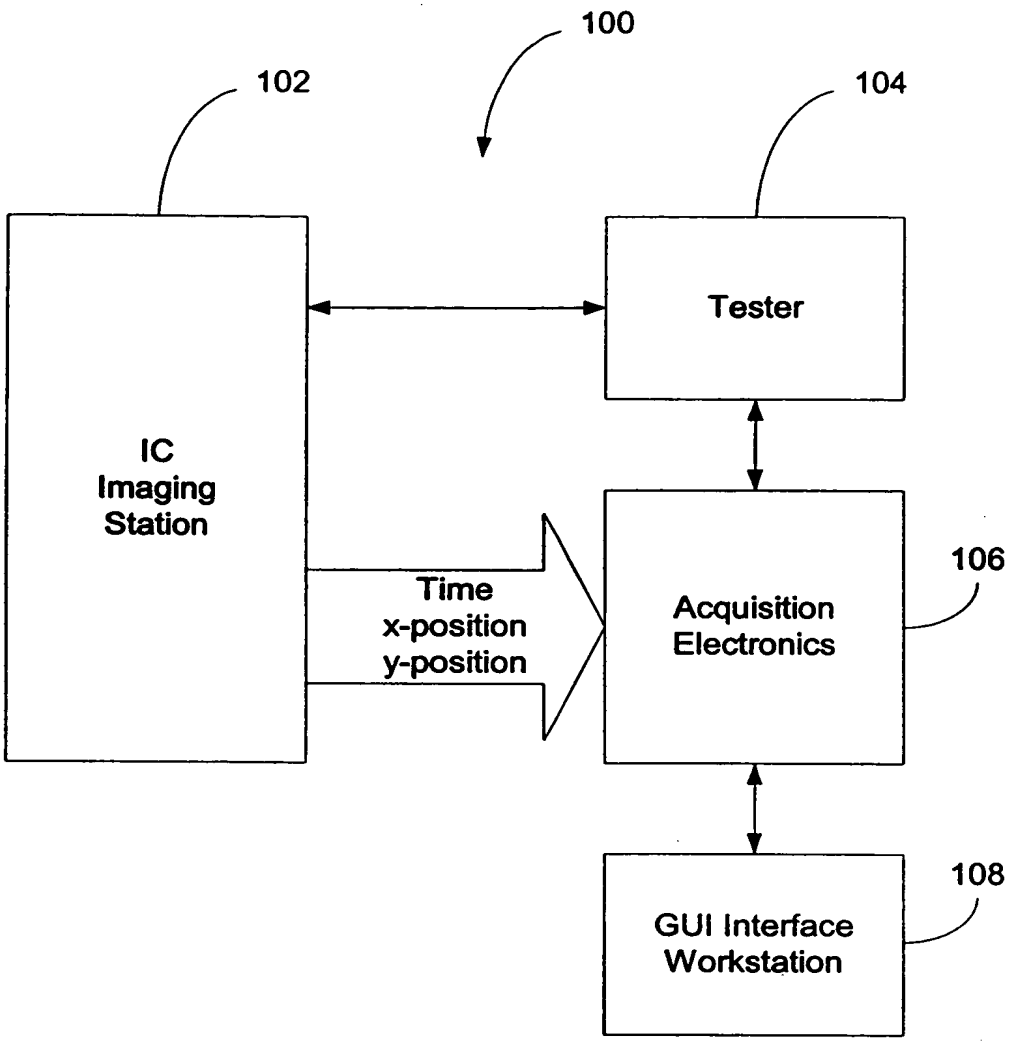

100
102
104
IC
Imaging
Station
Tester
Time
x-position
y-position
Acquisition
Electronics
106
GUI Interface
Workstation
108

FIG. 1

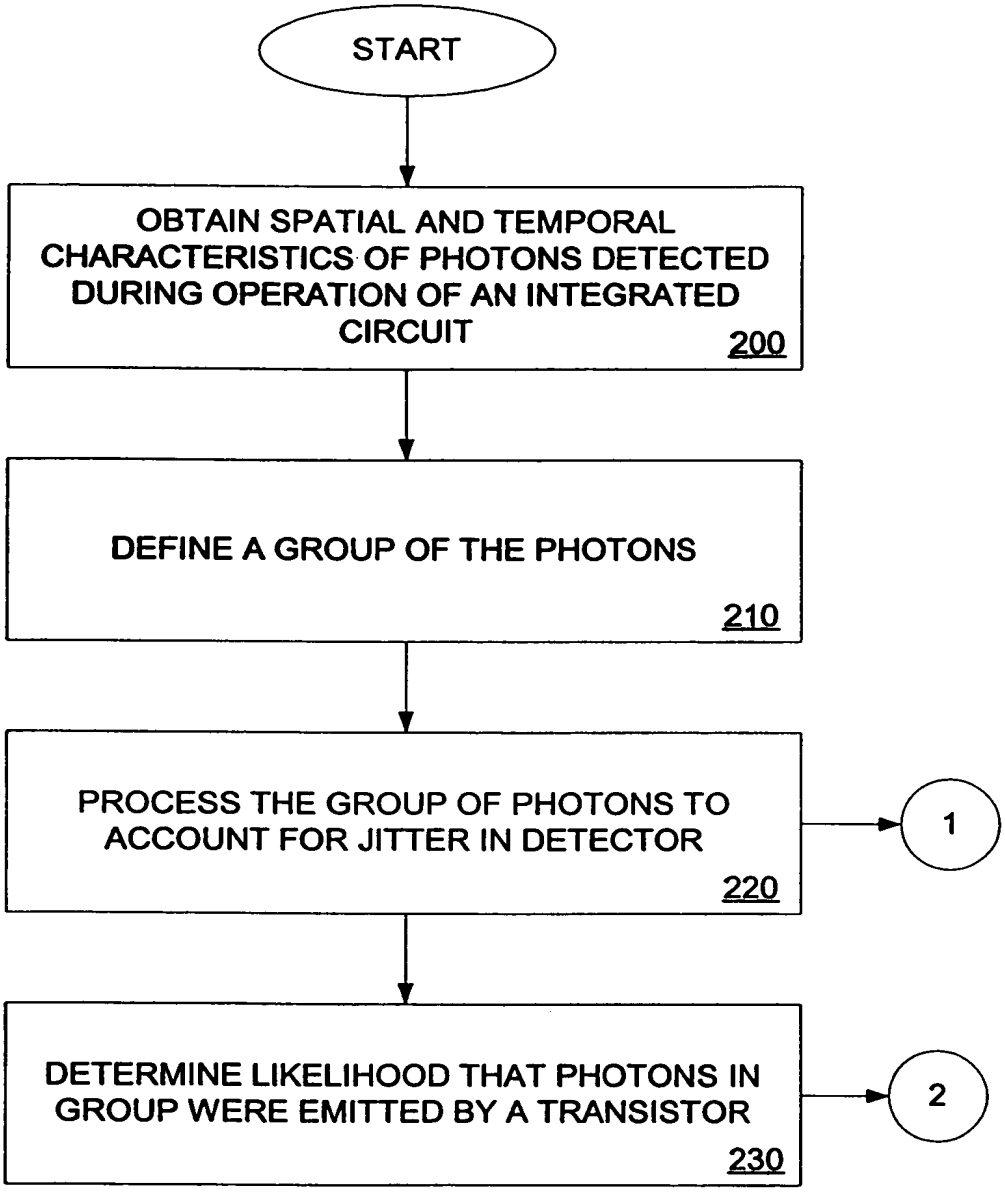

START
OBTAIN SPATIAL AND TEMPORAL CHARACTERISTICS OF PHOTONS DETECTED DURING OPERATION OF AN INTEGRATED CIRCUIT
200
DEFINE A GROUP OF THE PHOTONS
210
PROCESS THE GROUP OF PHOTONS TO ACCOUNT FOR JITTER IN DETECTOR
220
1
DETERMINE LIKELIHOOD THAT PHOTONS IN GROUP WERE EMITTED BY A TRANSISTOR
230
2

FIG. 2

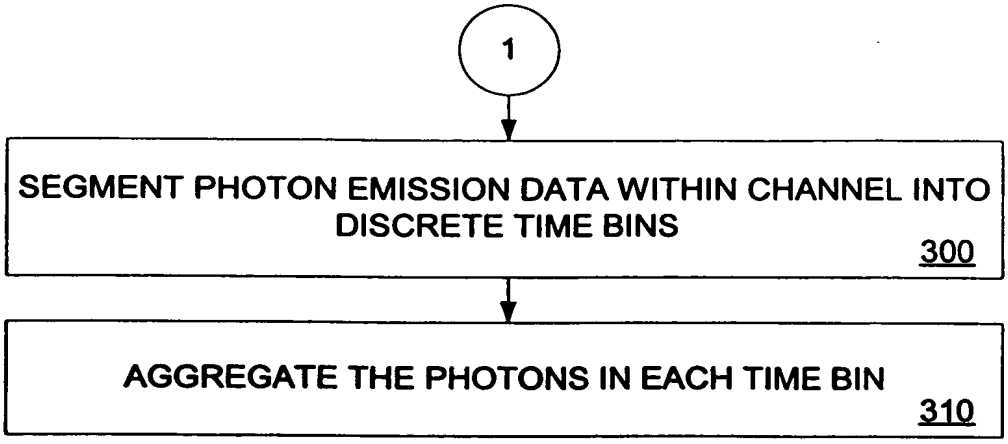


FIG. 3A

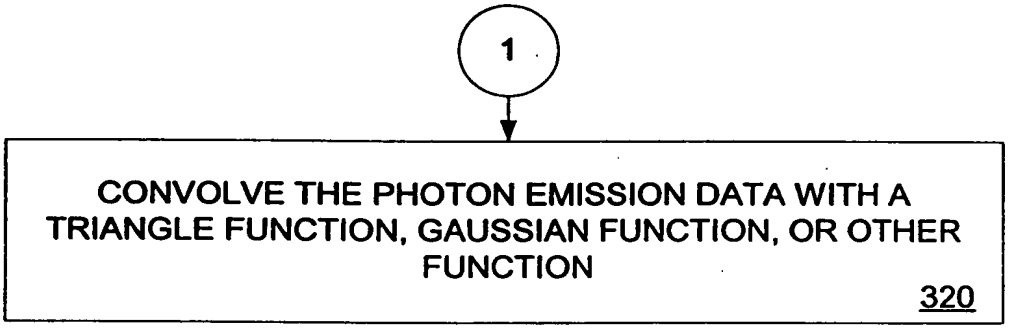


FIG. 3B

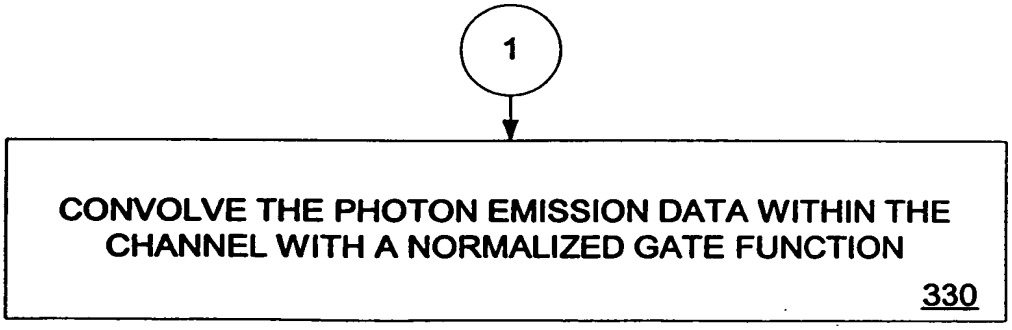


FIG. 3C

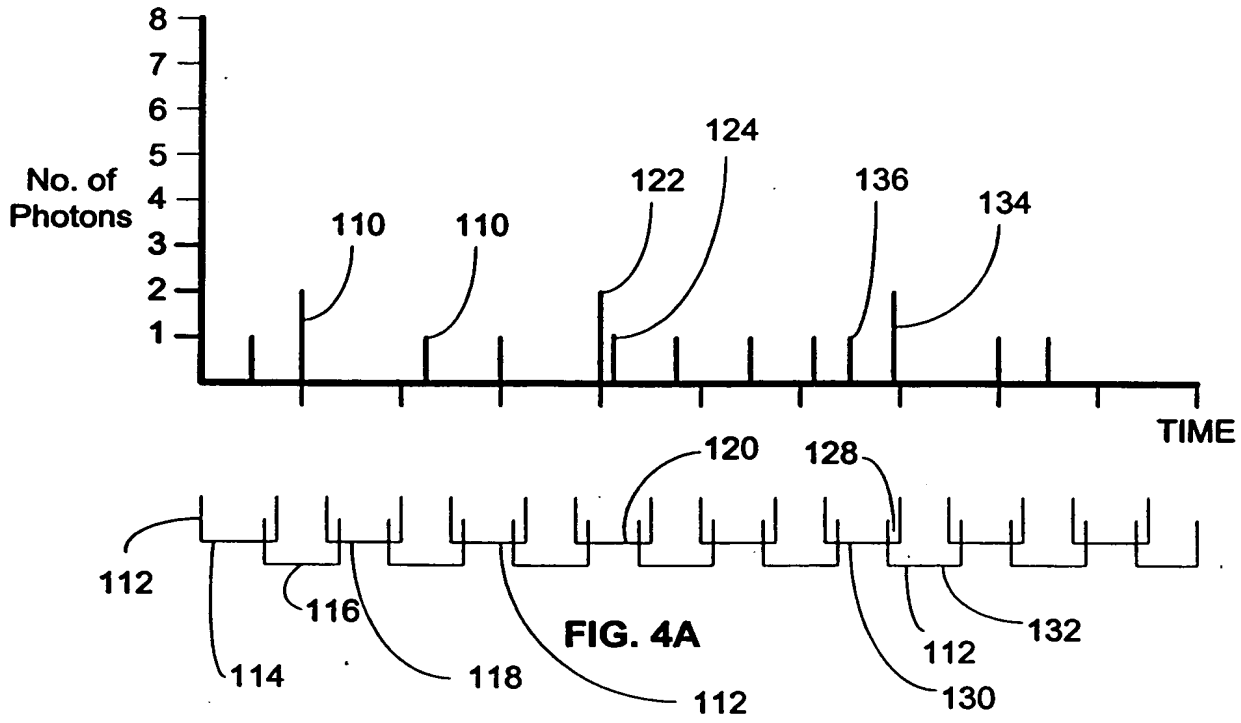

No. of Photons
8
7
6
5
4
3
2
1
110
110
122
124
136
134
TIME
120
128
112
116
114
118
112
112
130
132

FIG. 4A

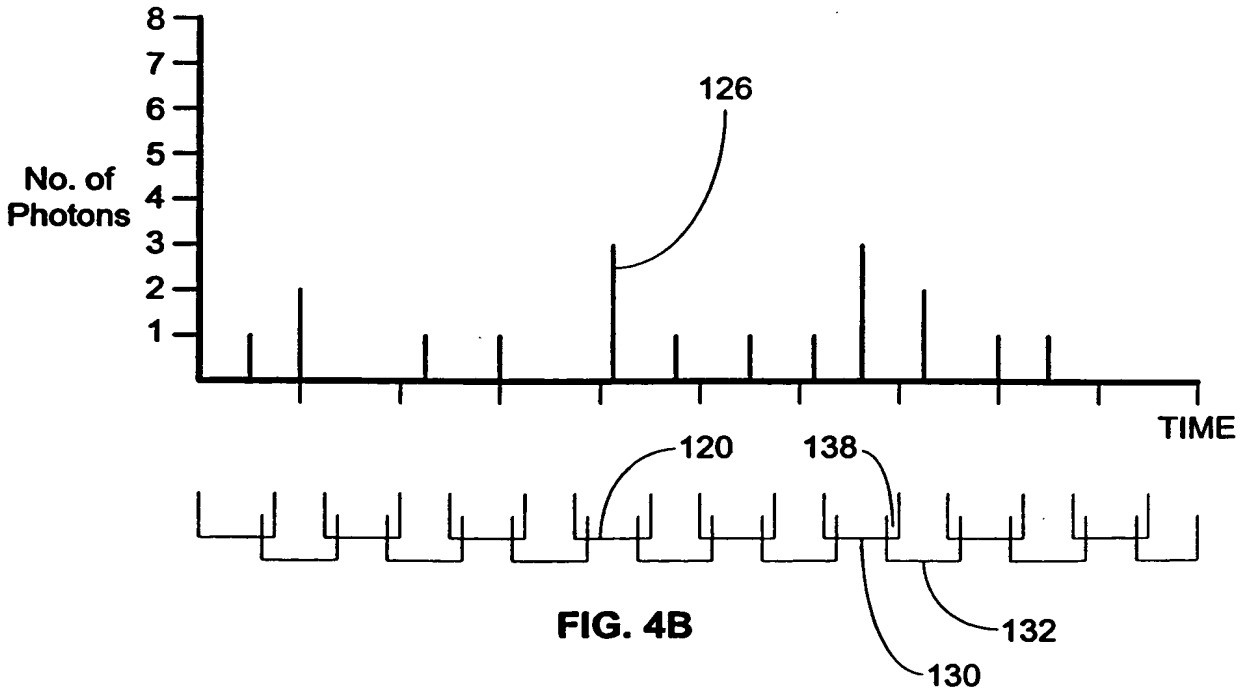

No. of Photons
8
7
6
5
4
3
2
1
126
TIME
120
138
132
130

FIG. 4B

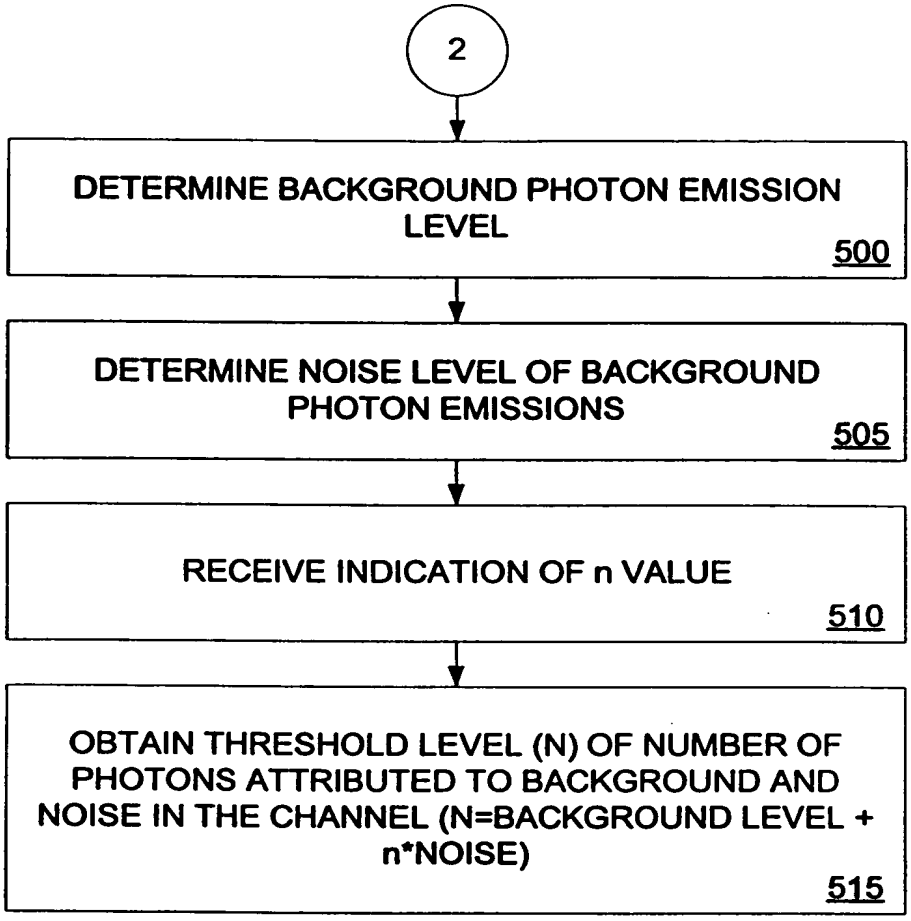

2
DETERMINE BACKGROUND PHOTON EMISSION LEVEL
500
DETERMINE NOISE LEVEL OF BACKGROUND PHOTON EMISSIONS
505
RECEIVE INDICATION OF n VALUE
510
OBTAIN THRESHOLD LEVEL (N) OF NUMBER OF PHOTONS ATTRIBUTED TO BACKGROUND AND NOISE IN THE CHANNEL (N=BACKGROUND LEVEL + n*NOISE)
515

FIG. 5A

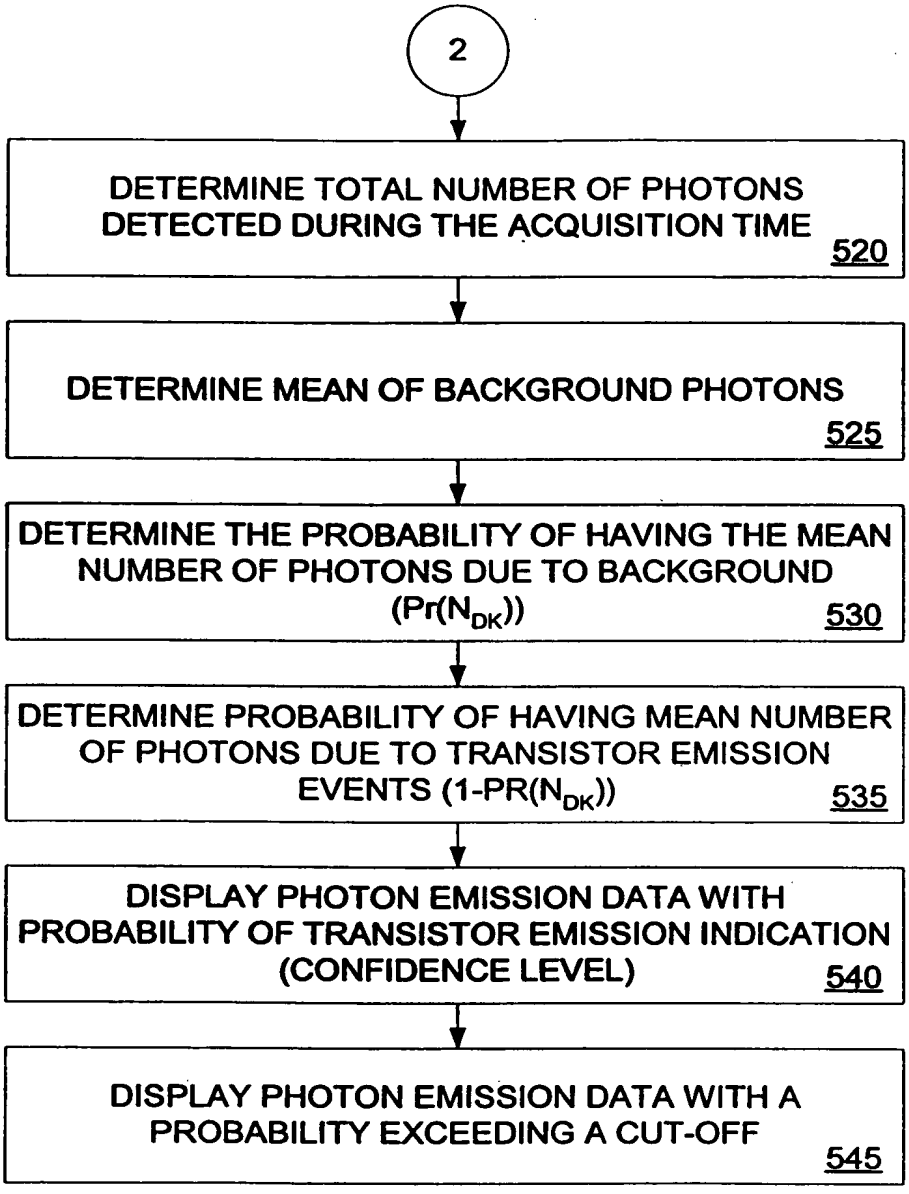

2
DETERMINE TOTAL NUMBER OF PHOTONS DETECTED DURING THE ACQUISITION TIME
520
DETERMINE MEAN OF BACKGROUND PHOTONS
525
DETERMINE THE PROBABILITY OF HAVING THE MEAN NUMBER OF PHOTONS DUE TO BACKGROUND ($Pr(N_{DK})$)
530
DETERMINE PROBABILITY OF HAVING MEAN NUMBER OF PHOTONS DUE TO TRANSISTOR EMISSION EVENTS ($1-PR(N_{DK})$)
535
DISPLAY PHOTON EMISSION DATA WITH PROBABILITY OF TRANSISTOR EMISSION INDICATION (CONFIDENCE LEVEL)
540
DISPLAY PHOTON EMISSION DATA WITH A PROBABILITY EXCEEDING A CUT-OFF
545

FIG. 5B

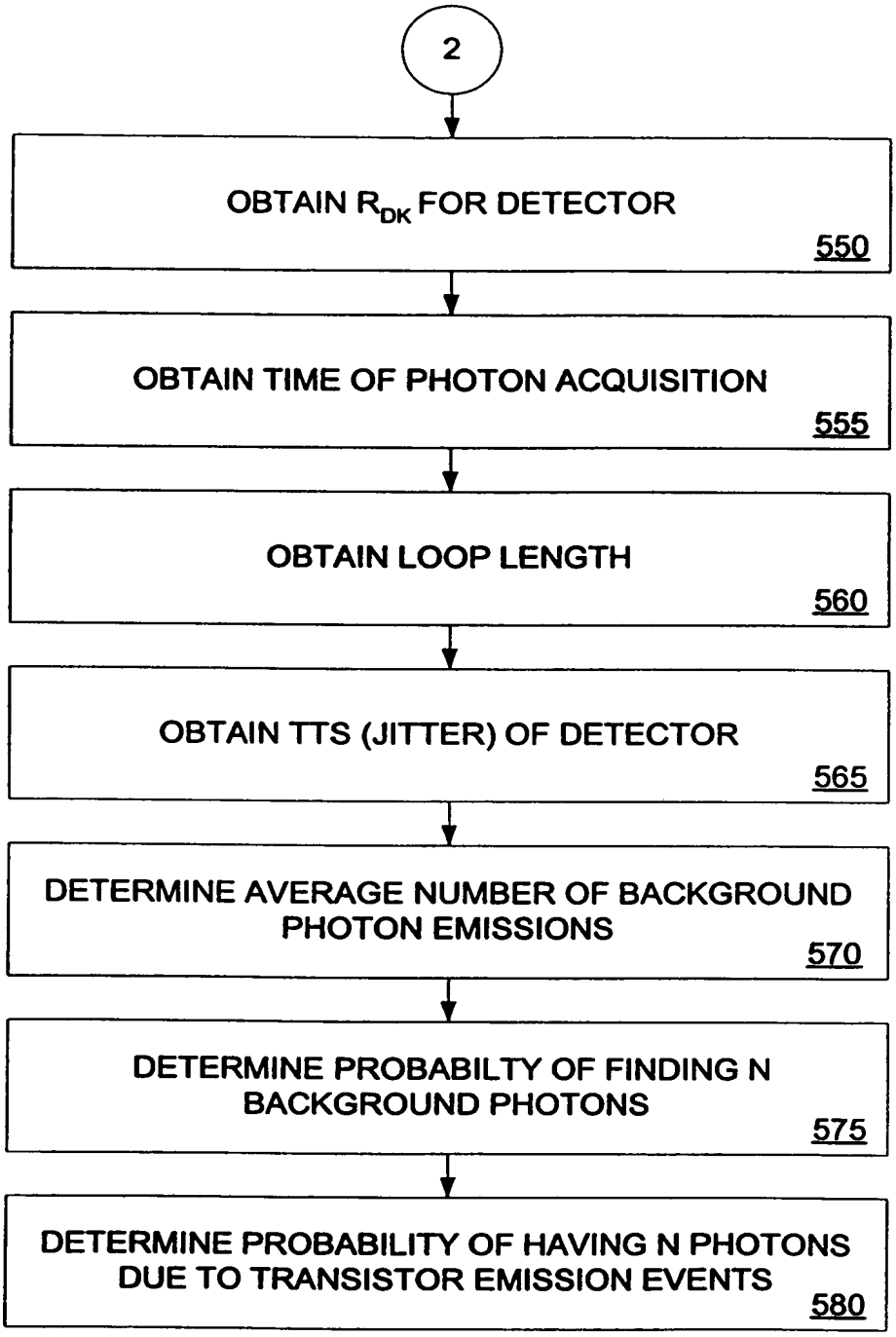

2
OBTAIN R_{DK} FOR DETECTOR
550
OBTAIN TIME OF PHOTON ACQUISITION
555
OBTAIN LOOP LENGTH
560
OBTAIN TTS (JITTER) OF DETECTOR
565
DETERMINE AVERAGE NUMBER OF BACKGROUND PHOTON EMISSIONS
570
DETERMINE PROBABILTY OF FINDING N BACKGROUND PHOTONS
575
DETERMINE PROBABILITY OF HAVING N PHOTONS DUE TO TRANSISTOR EMISSION EVENTS
580

FIG. 5C

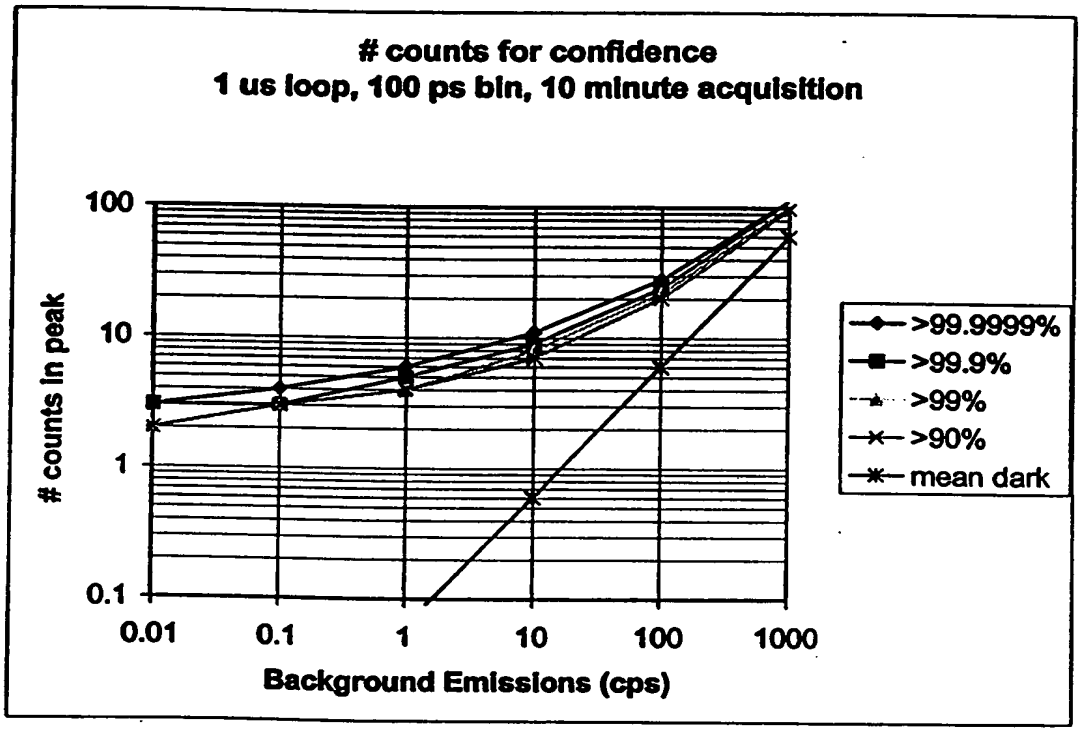

counts for confidence
1 us loop, 100 ps bin, 10 minute acquisition
counts in peak
100
10
1
0.1
0.01
0.1
1
10
100
1000
Background Emissions (cps)
>99.9999%
>99.9%
>99%
>90%
mean dark

FIG. 6

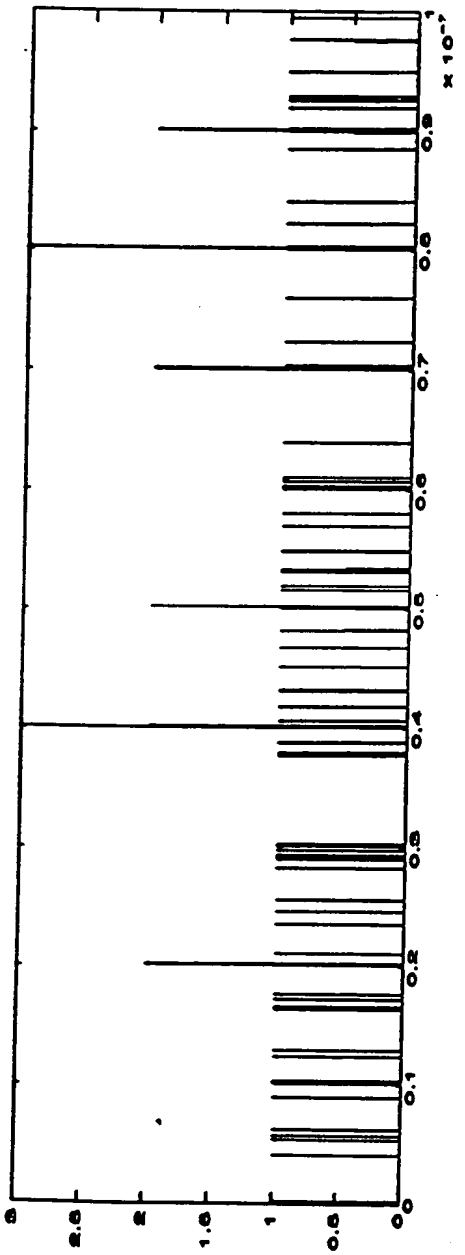


FIG. 7A

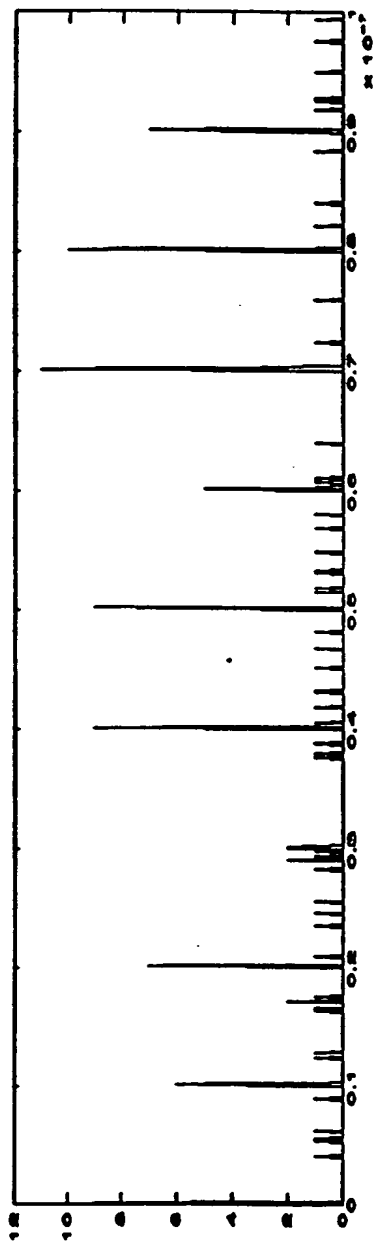


FIG. 7B

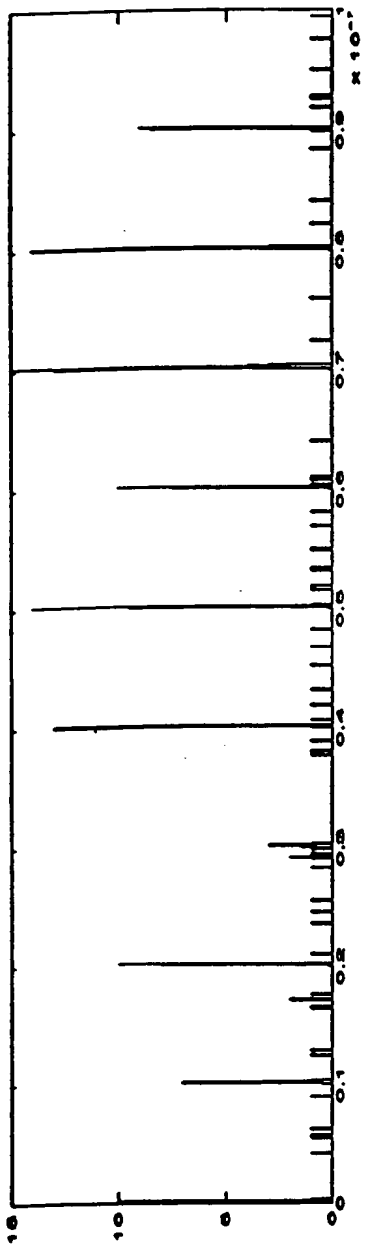


FIG. 7C

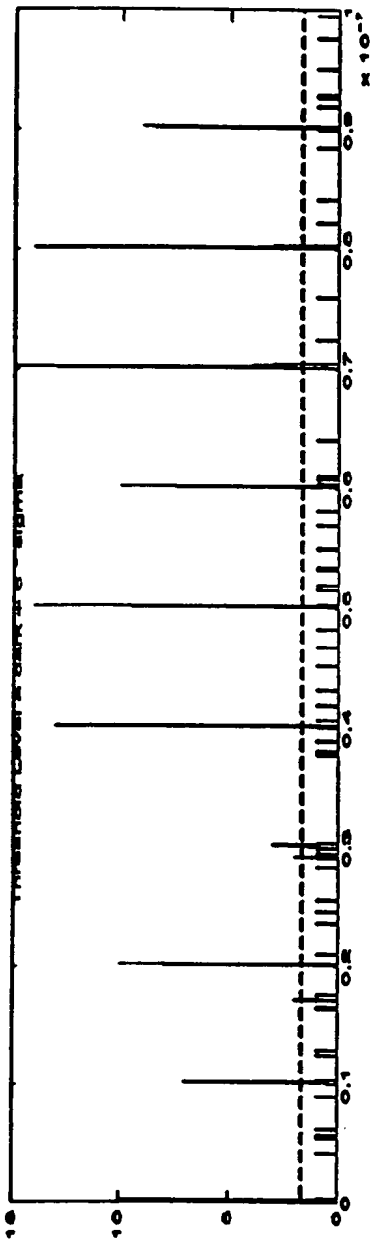


FIG. 7D

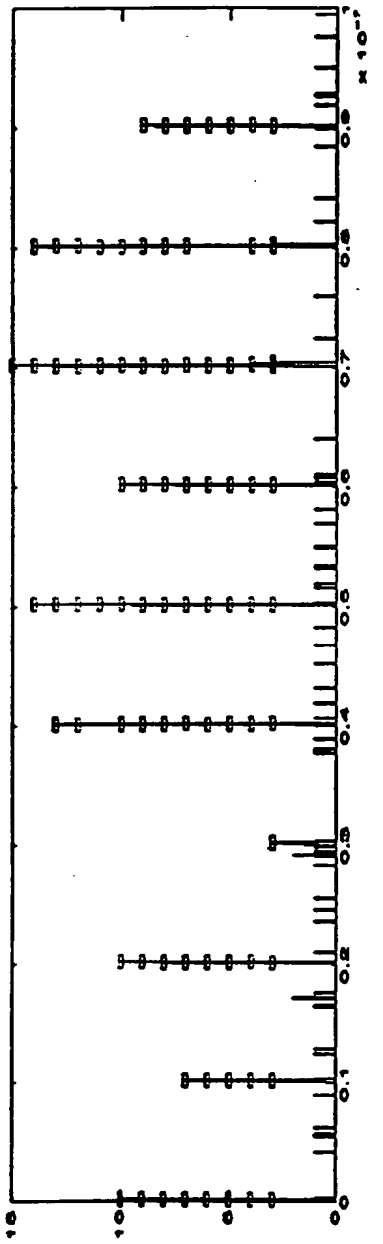


FIG. 7E

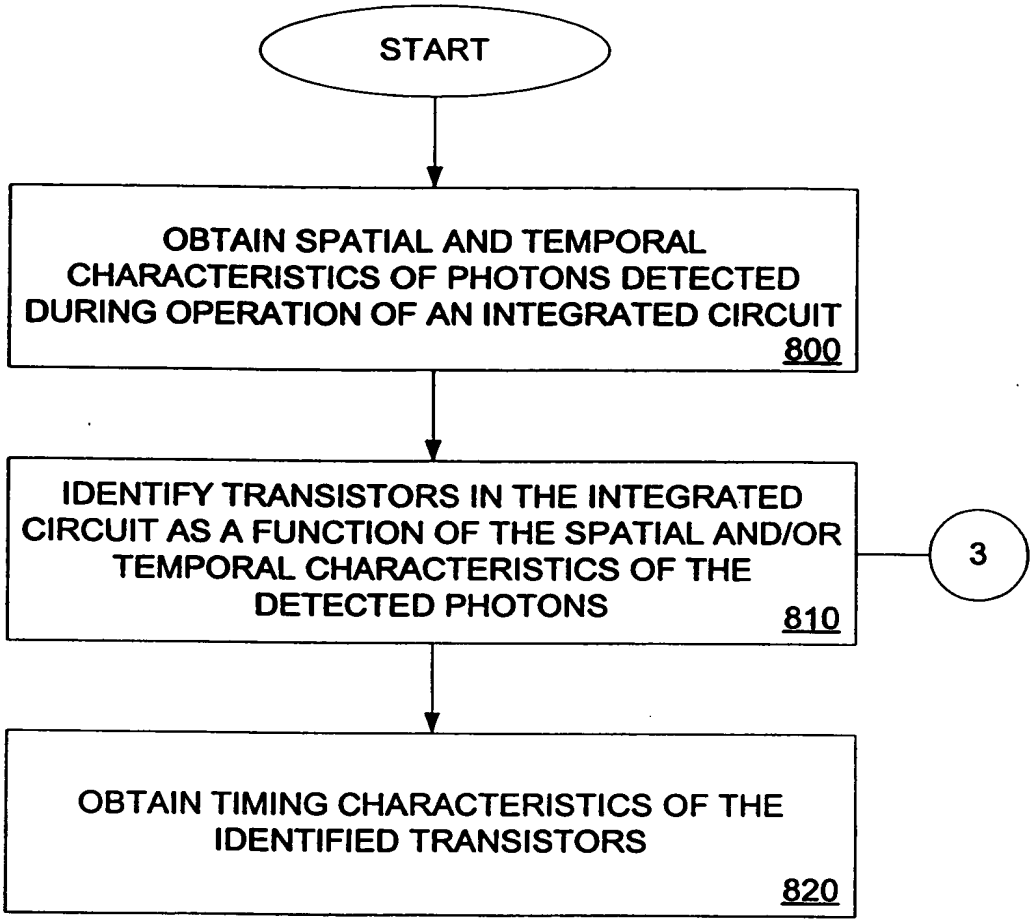

START
OBTAIN SPATIAL AND TEMPORAL CHARACTERISTICS OF PHOTONS DETECTED DURING OPERATION OF AN INTEGRATED CIRCUIT
800
IDENTIFY TRANSISTORS IN THE INTEGRATED CIRCUIT AS A FUNCTION OF THE SPATIAL AND/OR TEMPORAL CHARACTERISTICS OF THE DETECTED PHOTONS
810
3
OBTAIN TIMING CHARACTERISTICS OF THE IDENTIFIED TRANSISTORS
820

FIG. 8

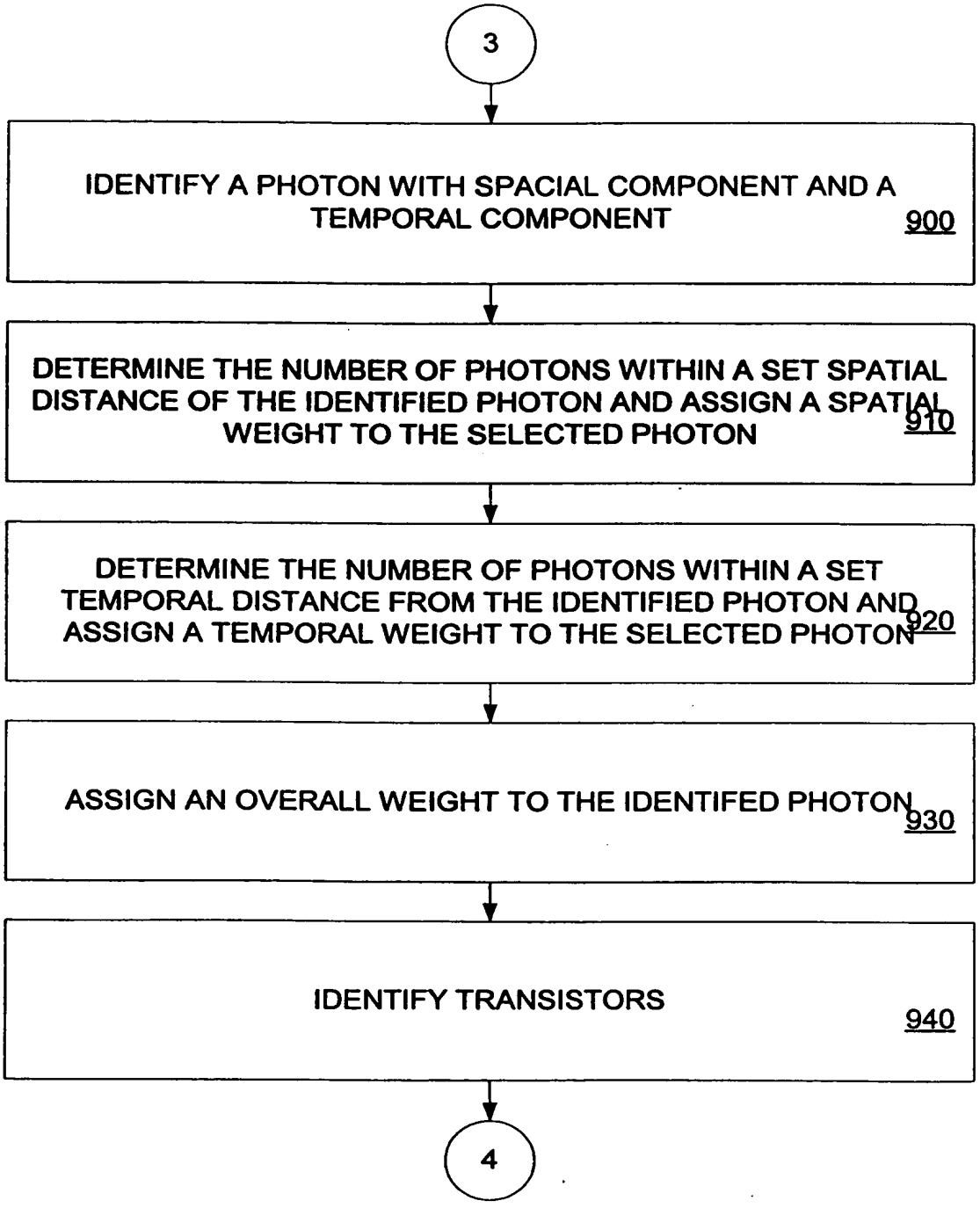

3
IDENTIFY A PHOTON WITH SPACIAL COMPONENT AND A TEMPORAL COMPONENT
900
DETERMINE THE NUMBER OF PHOTONS WITHIN A SET SPATIAL DISTANCE OF THE IDENTIFIED PHOTON AND ASSIGN A SPATIAL WEIGHT TO THE SELECTED PHOTON
910
DETERMINE THE NUMBER OF PHOTONS WITHIN A SET TEMPORAL DISTANCE FROM THE IDENTIFIED PHOTON AND ASSIGN A TEMPORAL WEIGHT TO THE SELECTED PHOTON
920
ASSIGN AN OVERALL WEIGHT TO THE IDENTIFED PHOTON
930
IDENTIFY TRANSISTORS
940
4

FIG. 9

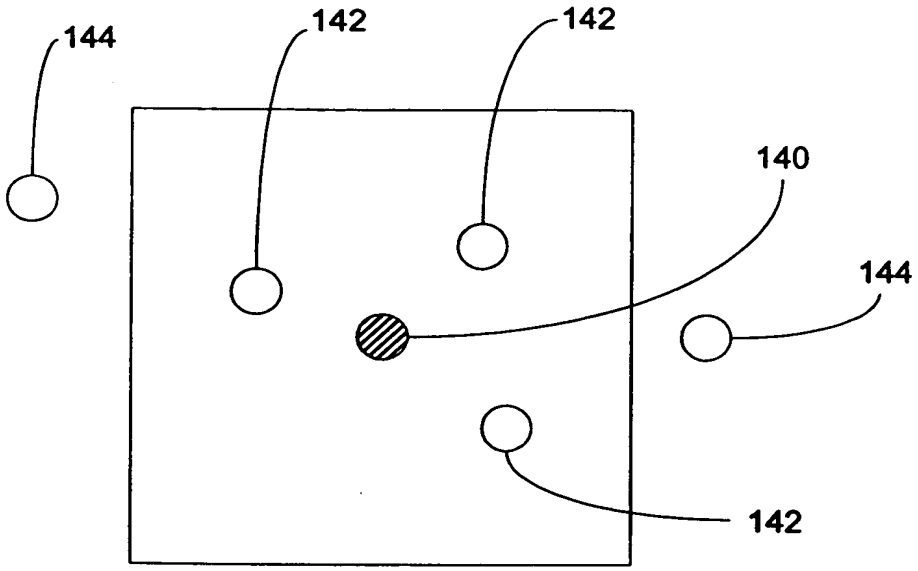


FIG. 10A

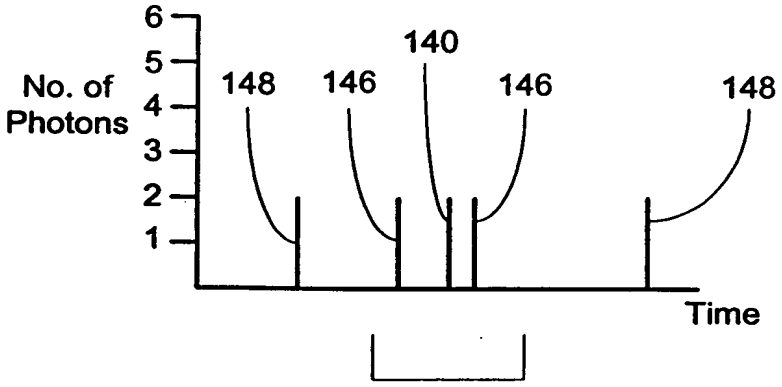


FIG.10B

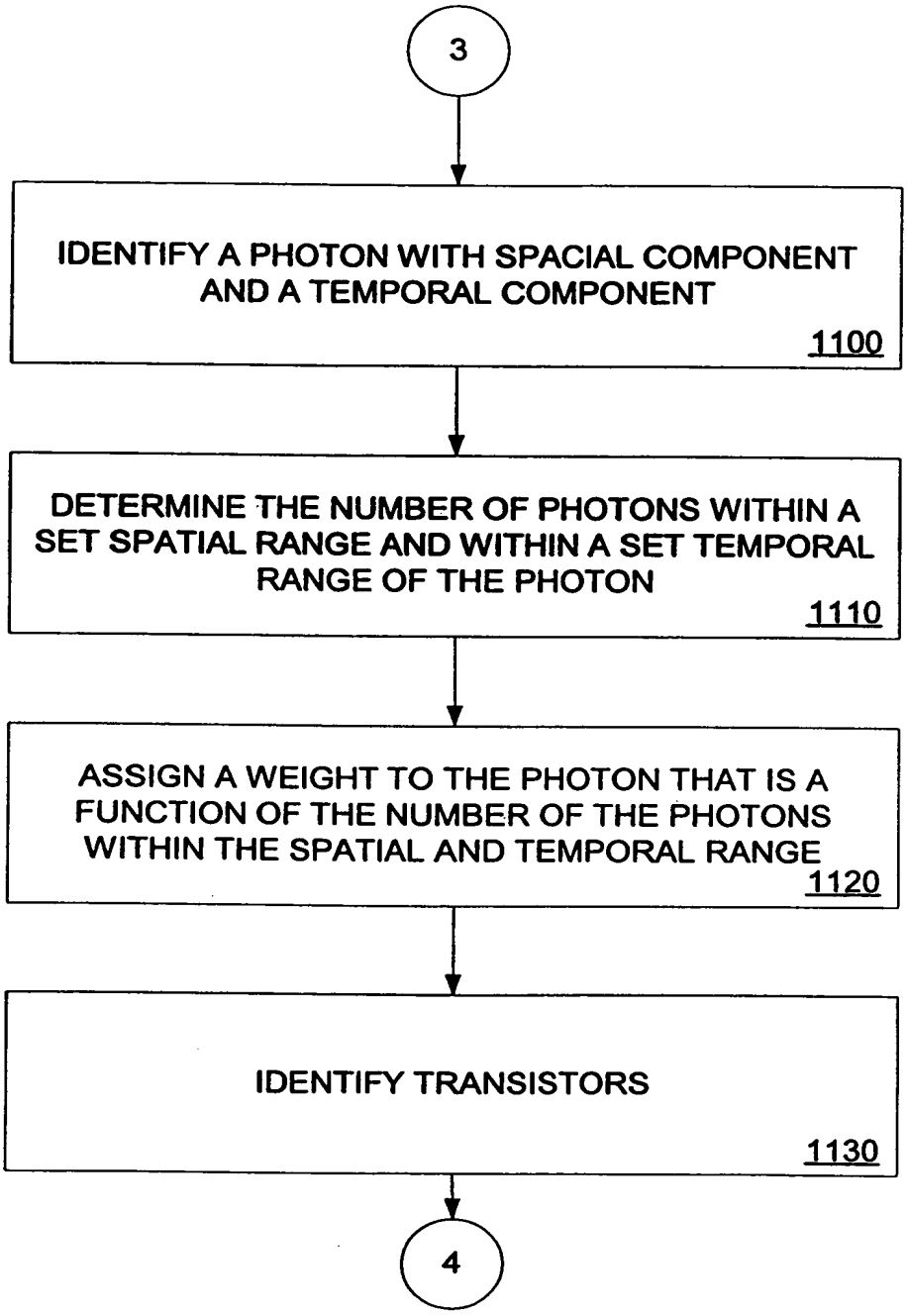

3
IDENTIFY A PHOTON WITH SPACIAL COMPONENT AND A TEMPORAL COMPONENT
1100
DETERMINE THE NUMBER OF PHOTONS WITHIN A SET SPATIAL RANGE AND WITHIN A SET TEMPORAL RANGE OF THE PHOTON
1110
ASSIGN A WEIGHT TO THE PHOTON THAT IS A FUNCTION OF THE NUMBER OF THE PHOTONS WITHIN THE SPATIAL AND TEMPORAL RANGE
1120
IDENTIFY TRANSISTORS
1130
4

FIG. 11

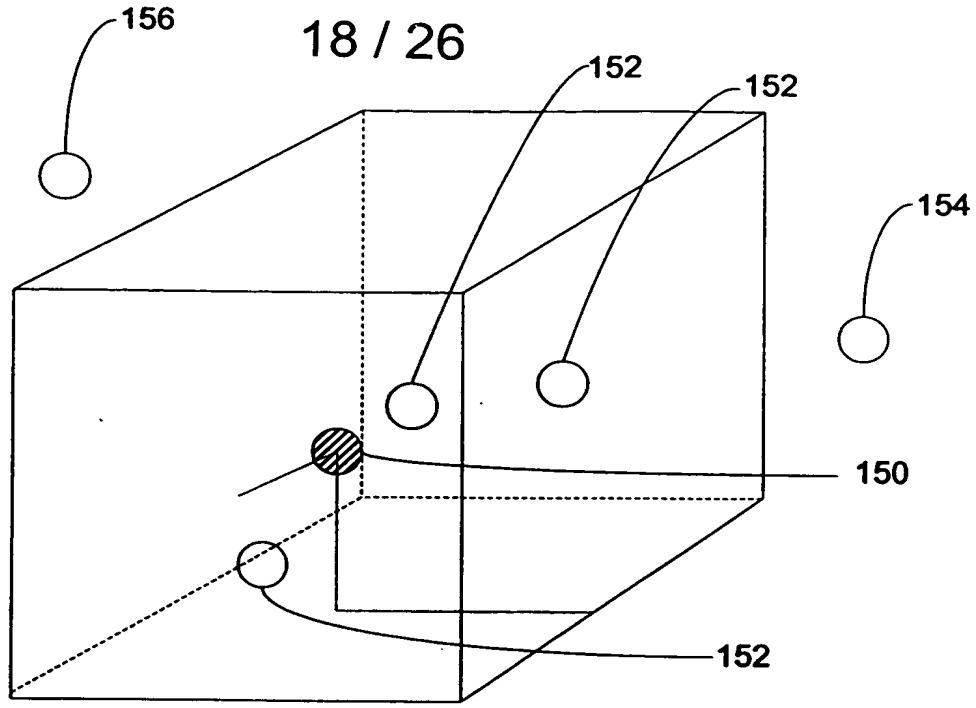


FIG. 12A

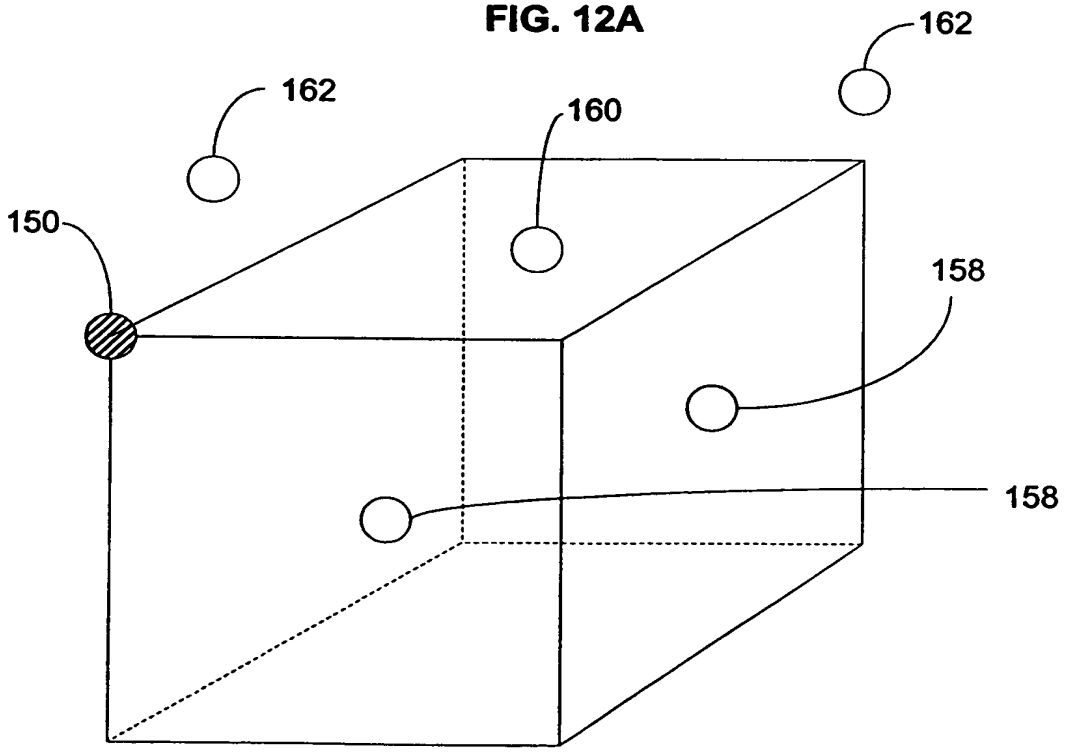


FIG. 12B

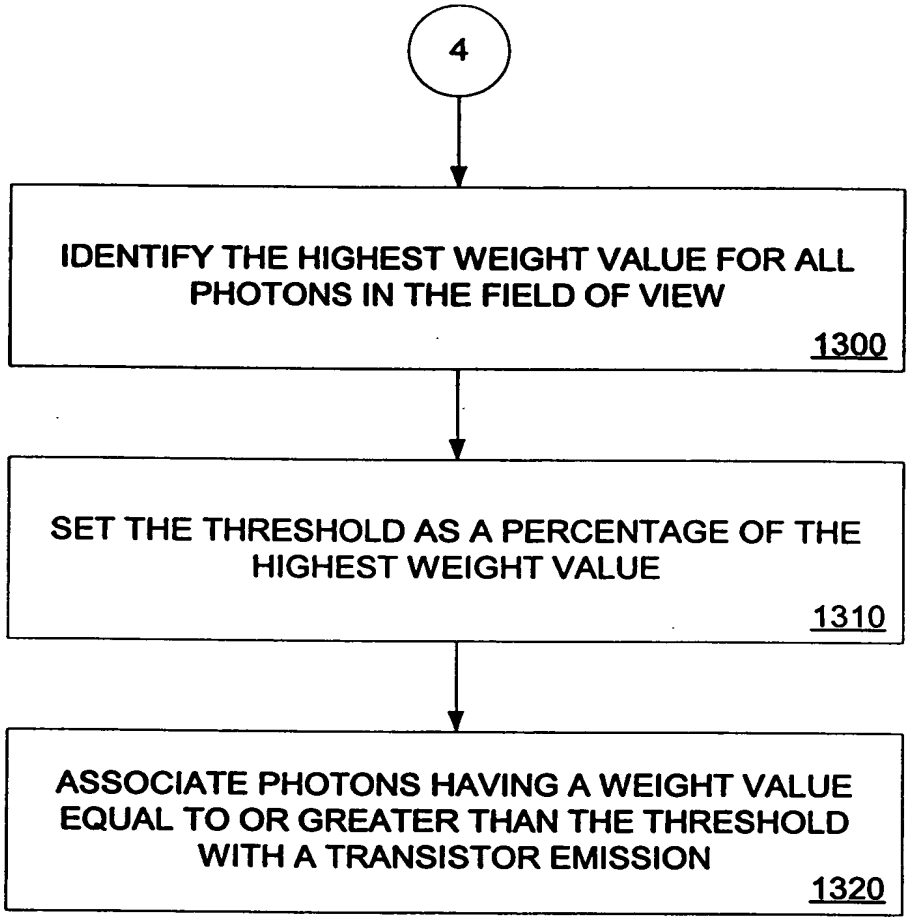

4
IDENTIFY THE HIGHEST WEIGHT VALUE FOR ALL PHOTONS IN THE FIELD OF VIEW
1300
SET THE THRESHOLD AS A PERCENTAGE OF THE HIGHEST WEIGHT VALUE
1310
ASSOCIATE PHOTONS HAVING A WEIGHT VALUE EQUAL TO OR GREATER THAN THE THRESHOLD WITH A TRANSISTOR EMISSION
1320

FIG. 13

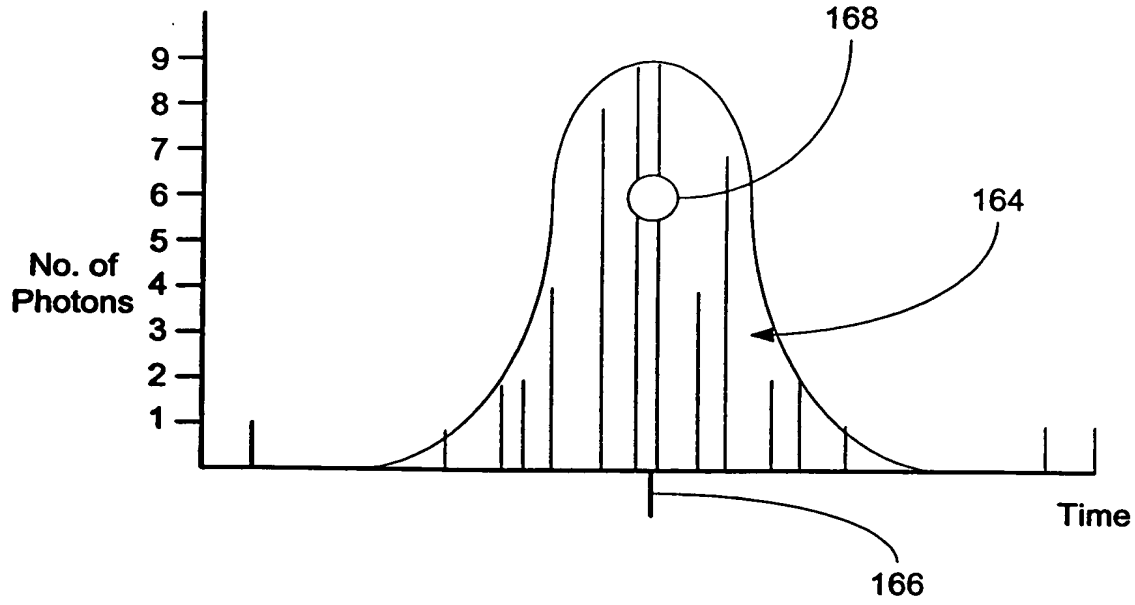


FIG. 14A

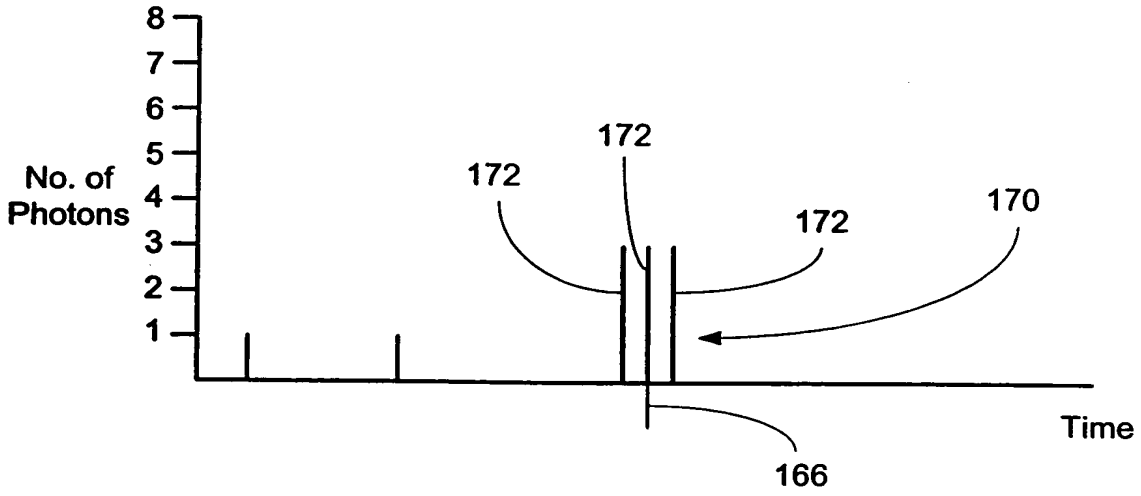


FIG. 14B

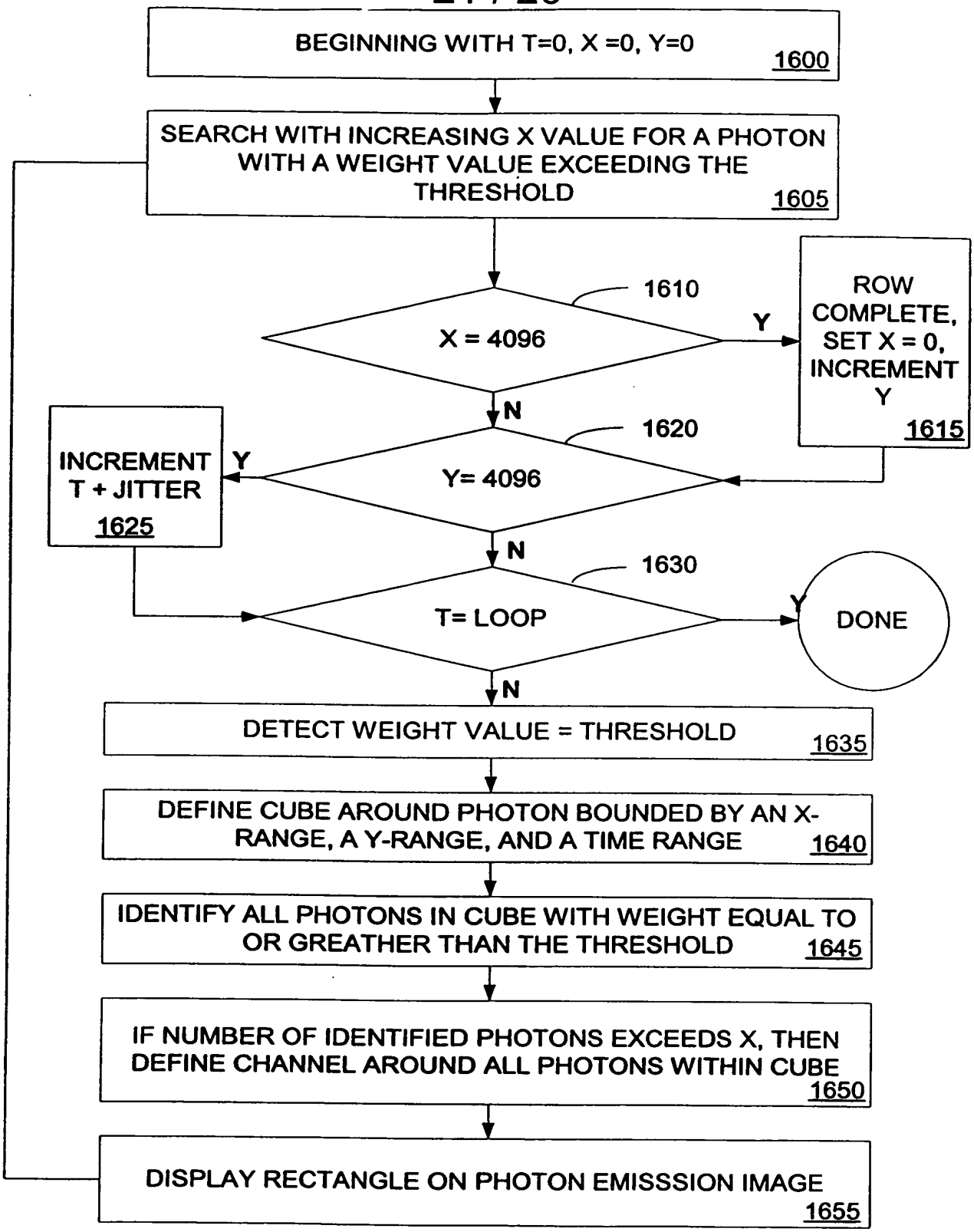

BEGINNING WITH T=0, X =0, Y=0
1600
SEARCH WITH INCREASING X VALUE FOR A PHOTON WITH A WEIGHT VALUE EXCEEDING THE THRESHOLD
1605
1610
X = 4096
Y
ROW COMPLETE, SET X = 0, INCREMENT Y
1615
N
1620
Y= 4096
Y
INCREMENT T + JITTER
1625
N
1630
T= LOOP
Y
DONE
N
DETECT WEIGHT VALUE = THRESHOLD
1635
DEFINE CUBE AROUND PHOTON BOUNDED BY AN X-RANGE, A Y-RANGE, AND A TIME RANGE
1640
IDENTIFY ALL PHOTONS IN CUBE WITH WEIGHT EQUAL TO OR GREATHER THAN THE THRESHOLD
1645
IF NUMBER OF IDENTIFIED PHOTONS EXCEEDS X, THEN DEFINE CHANNEL AROUND ALL PHOTONS WITHIN CUBE
1650
DISPLAY RECTANGLE ON PHOTON EMISSSION IMAGE
1655

FIG. 15

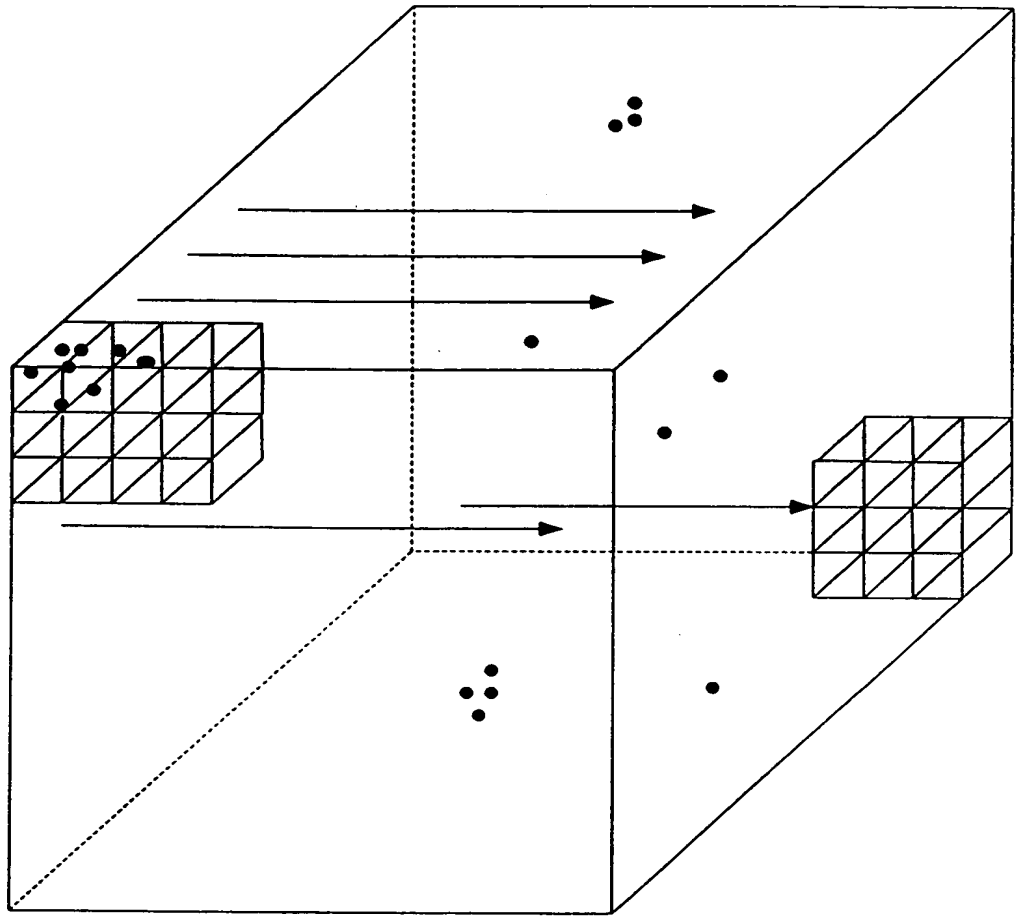


FIG. 16

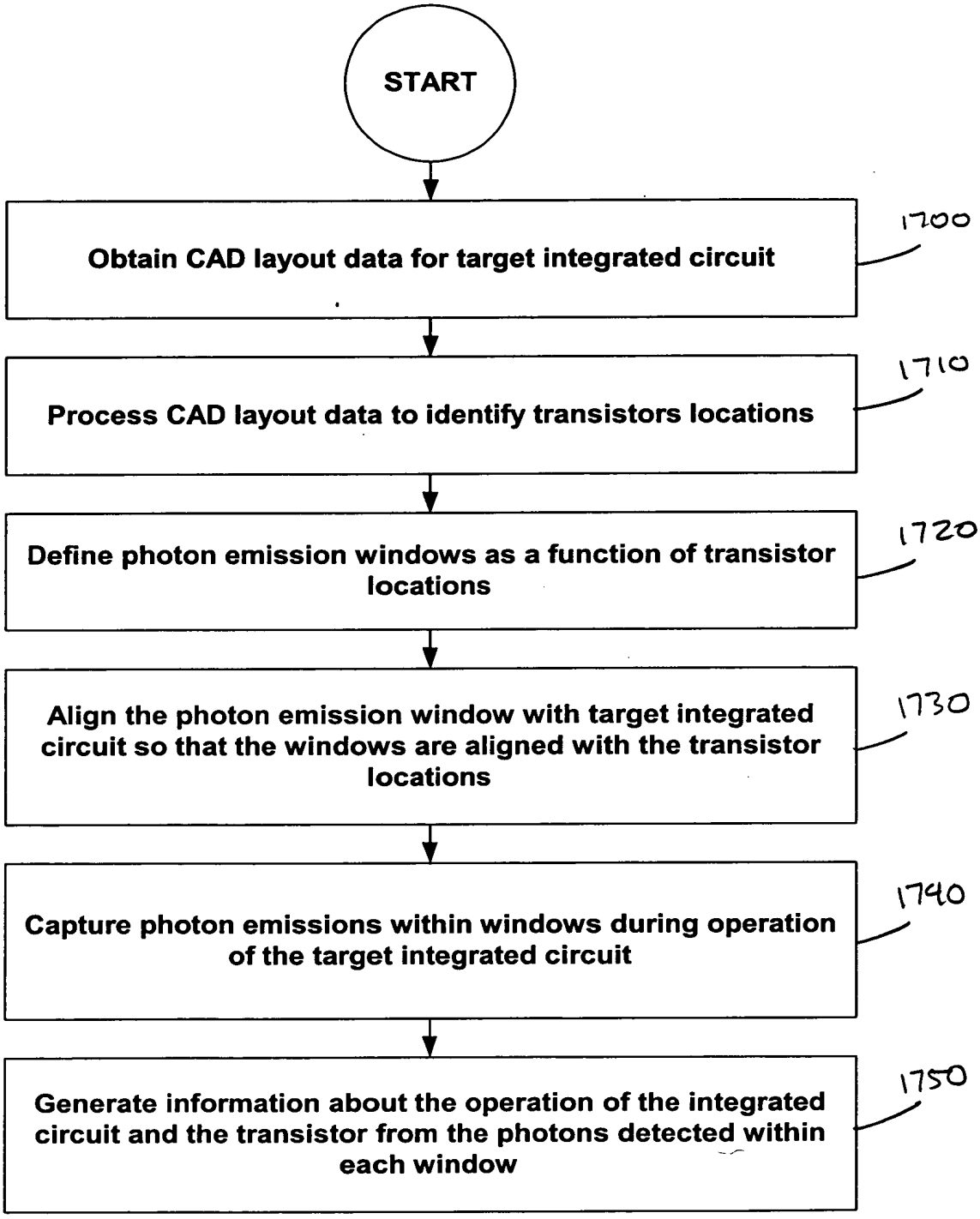

START
Obtain CAD layout data for target integrated circuit
1700
Process CAD layout data to identify transistors locations
1710
Define photon emission windows as a function of transistor locations
1720
Align the photon emission window with target integrated circuit so that the windows are aligned with the transistor locations
1730
Capture photon emissions within windows during operation of the target integrated circuit
1740
Generate information about the operation of the integrated circuit and the transistor from the photons detected within each window
1750

FIG. 17

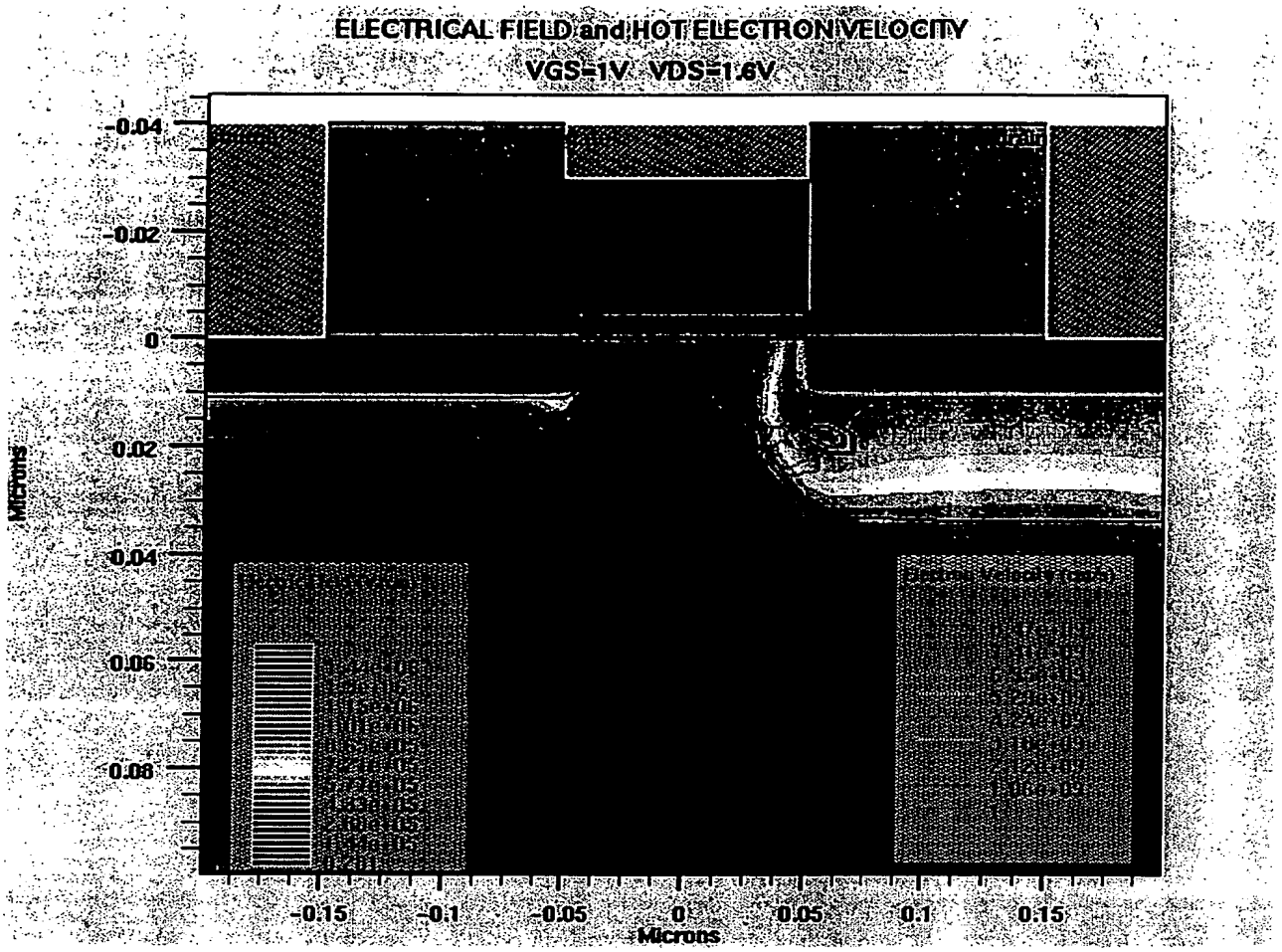
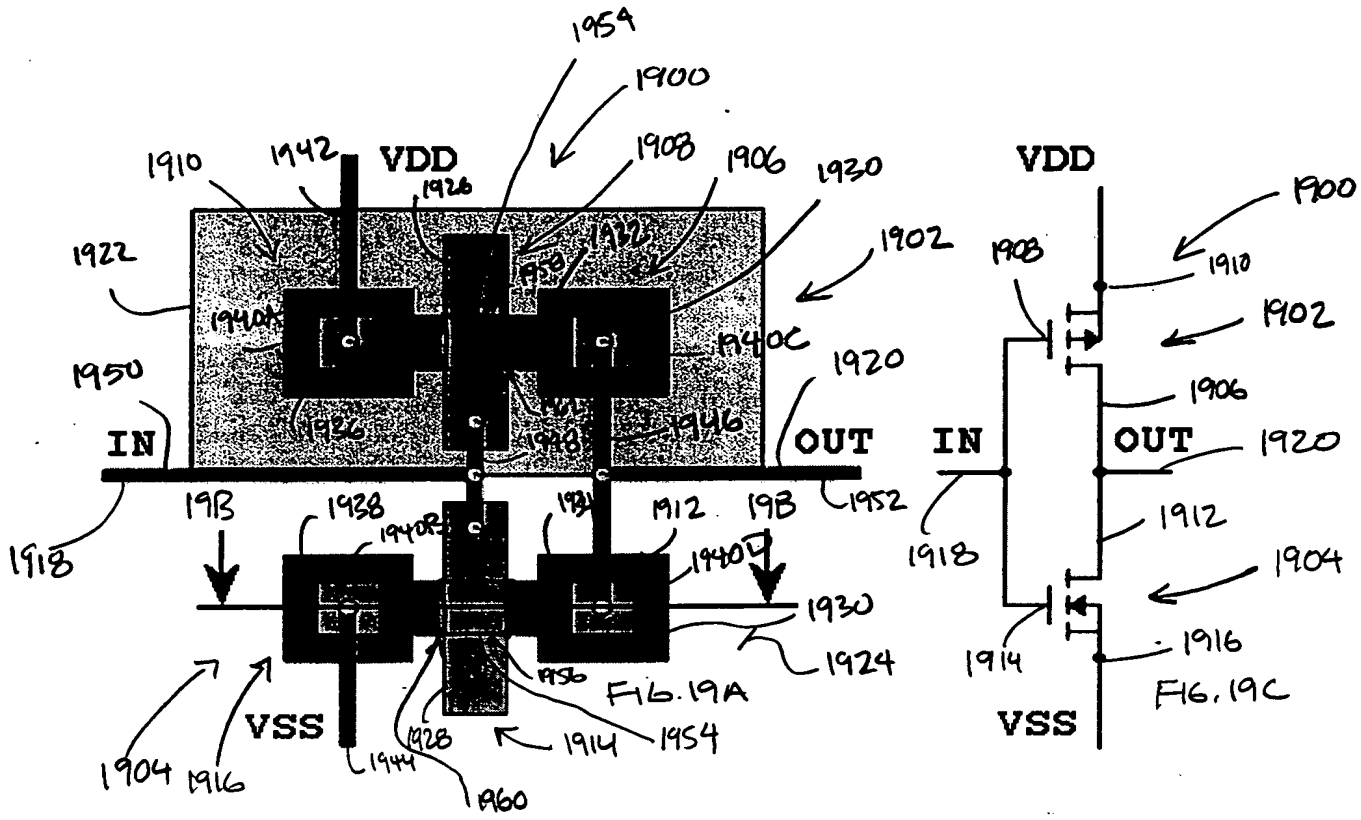


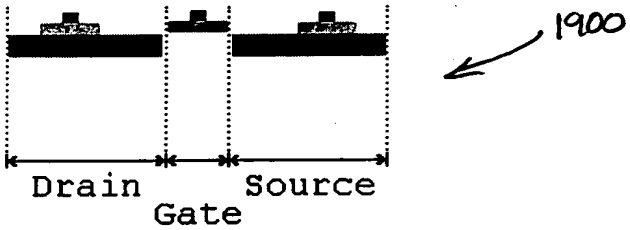
FIG. 18

BEST AVAILABLE COPY



F16.19A

F16.19C



F16. 19B

BEST AVAILABLE COPY

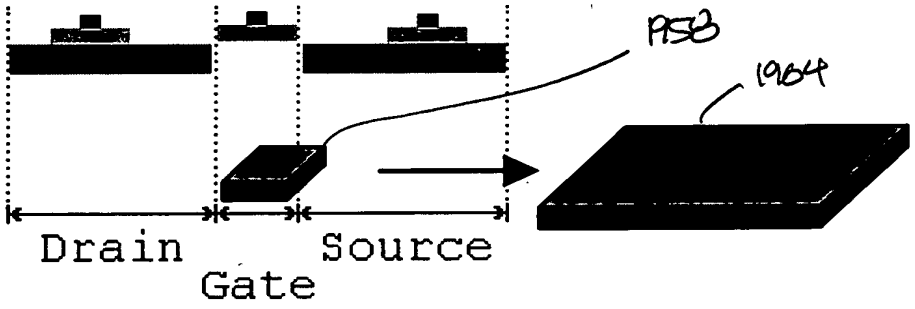


FIG. 20

BEST AVAILABLE COPY